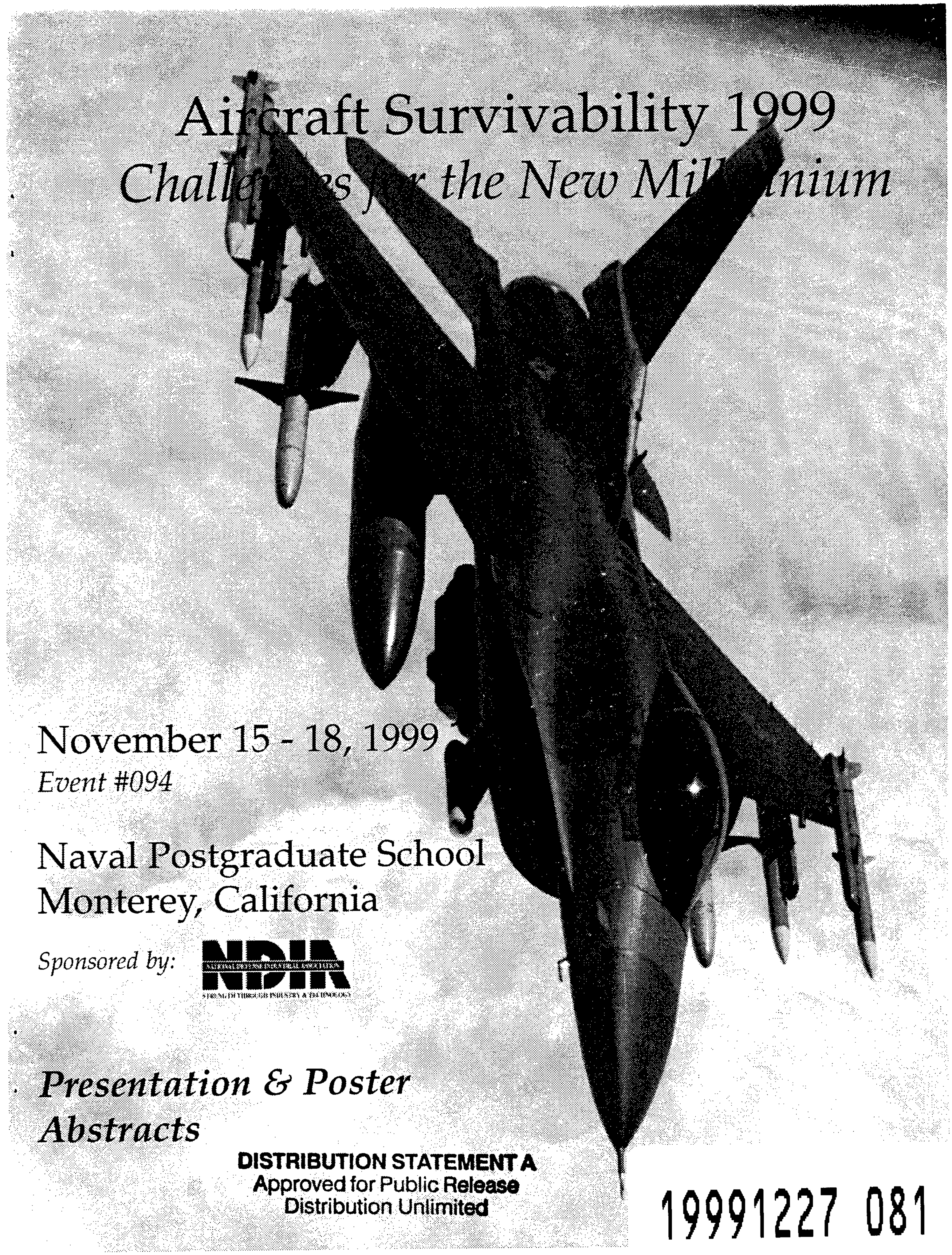

# Aircraft Survivability 1999
## *Challenges for the New Millennium*

November 15 - 18, 1999
*Event #094*

Naval Postgraduate School
Monterey, California

*Sponsored by:* NDIA
NATIONAL DEFENSE INDUSTRIAL ASSOCIATION
STRENGTH THROUGH INDUSTRY & TECHNOLOGY

***Presentation & Poster Abstracts***

# *Presentation Abstracts*

## *ABSTRACT*

**CM What Works, What Doesn't**


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The Precision Guided Weapons (PGW) Countermeasures (CM) Test and Evaluation Directorate (OTD) has been evaluating CM effectiveness against Electro-optical and infrared guided (EO/IR) weapons since 1972. As part of our charter, OTD has evaluated the effectiveness of CM in protecting various types of U.S. aircraft against a variety of Man Portable Air Defense Systems (MANPADS).

This paper will examine countermeasures from three different aspects. The first is the need for detection of the incoming missile. If you don't know it's coming, it is hard to take action. In this segment, video clips of MANPADS missile engagements will be shown, both from an external view, and from a pilot's eye view.

The second part of the briefing will present a discussion of CM effectiveness against various types of MANPADS missiles. Using data collected during the IR Band IV CM JT&E and subsequent programs, countermeasures that were effective against selected missiles will be presented. To enhance the experience, video clips will be shown that provide the audience with a view of where the missile is looking so that they can better visualize the missile seeker's response to the CM.

The final part of the presentation will show footage of live fire engagements between drone aircraft and MANPADS missiles. A discussion will be provided of the results of the engagements.

The presentation will conclude with a summary of the types of information available about test results of CM protecting U.S. aircraft against EO/IR guided missiles.

# DEFEATING THE THREAT AT LOW ALTITUDE

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The trend in the air defense threat is not favorable to Army Aviation. Even export versions of most threat systems are becoming more sophisticated and being proliferated to a high degree. Man Portable Air Defense (MANPAD) systems like the Stinger, SA-7b, and SA-18 are lightweight and effective as demonstrated by Afghan Rebel forces. IR missiles account for well over half the combat aircraft losses since the Arab-Israeli conflict of 1974. Air defense missiles are becoming more sophisticated with integrated seeker heads and are becoming less susceptible to traditional active countermeasures.

Army Aviation has developed a four-step philosophy to mitigate the air defense threat. That philosophy is: I) Avoid Detection, II) Avoid Engagement, III) Avoid Damage, and IV) Survive Damage. Army Aviation invests heavily in Step I: Avoid Detection, through the use of low observable (LO) technologies to obtain the highest return on investment with regard to mission success, loss of life, and damaged equipment. LO technology investments are balanced by an equal investment in active countermeasures, aircraft hardening, situational awareness/ (tactics expert) and aircrew survivability technologies.

Army Aviation employs a number of passive LO technologies to avoid detection by enemy air defenses. These technologies are used to reduce IR, RF, visual/EO, and acoustic signatures of Army Aircraft.

Army Aviation employs mission planning technologies, enroute planning technologies called a "tactics expert" function, and advanced sensors to provide target standoff from enemy air defenses. The objective is to remain outside threat systems' maximum effective range to avoid engagement. Using enemy intelligence and real-time battlefield threat information from organic and other data feeds, the tactics expert can plan and propose solutions to avoid engagement with the enemy. Advanced sensors include Second Generation Forward Looking InfraRed ($2^{nd}$ Gen FLIR), Image Intensified Television (I2TV), and Millimeter Wave (MMW) Radar. Sensors, with the help of the tactics expert, have the ability to detect, classify, identify and prioritize enemy and friendly vehicles.

Once engaged, Army Aviation relies on the Suite of Integrated IR Countermeasures (SIIRCM) to actively defeat the IR missile threat. Similarlty, the Suite of Integrated RF Countermeasures is the primary active system to defeat RF threats. Army Aviation relies on aircraft hardening, system redundancy and aircrew survivability equipment as well to counter anti-aircraft, laser and EMP threats.

**Spacecraft – A New Frontier for Aerospace Survivability**

*by*

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and

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The military use of space began in 1957 with the launch of Sputnik. From this meager start, military use of space has grown exponentially. This dependence was best illustrated during Desert Storm. During those months in the Persian Gulf. over 95% of all information went through space. This has led to the conclusion by the National Air Intelligence Center that "Deception, disruption, denial or destruction of these space systems and service could seriously affect US warfighting capabilities." In addition, the US will place another 1,800 satellites on orbit by the end of the next decade. As General Howell Estes, former Commander of Space Command stated "this skyrocketing investment must be protected – from natural and man-made threats." There is also a misconception that the military relies primarily on military satellites to perform its mission while, in fact, the opposite is true. A recent study from the NDIA shows that over 80% of all DoD communications will pass through the commercial communications satellite infrastructure by the year 2010. The fragility of commercial assets was illustrated in 1998 when the Galaxy IV satellite was destroyed. This stopped pager service to 45 million people, 90% of all US pager users, for three days. Three days may be a minor inconvenience in civilian life, but wars are won or lost in this time.

Over the years, robust methodologies have been developed for quantifying and reducing the vulnerability of combat aircraft to directed threats. These disciplines have led to the establishment of probability-based survivability requirements, standards, design techniques and other enhancements. The objective of this presentation will be 910 to highlight the dependence of aircraft survivability and effectiveness on spacecraft assets, (2) to discuss the nature of spacecraft survivability threats, and (3) to consider the applicability of aircraft vulnerability assessment methodologies for quantifying and enhancing spacecraft survivability.

# U.S. MARINE CORPS REQUIREMENTS FOR AIRCRAFT SURVIVABILITY

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The Marine Corps is navigating through a significant period of transformation. Uncertainty in the world environment, technological proliferation, requirements for involvement across a broad spectrum of military operations and fiscal constraints place great demands on Marine Corps Aviation. This presentation describes the U.S. Marine Corps operational view on requirements for aircraft survivability during this time of transformation.

Innovative adaptation to the challenges of the $21^{st}$ century led to the development of the Operational Maneuver From The Sea (OMFTS) Concept. Supported by multiple ancillary concepts and core competencies, OMFTS is a revolution of ideas and technology. Survivability is woven into the fabric of those ideas and the resulting mission effectiveness. As Marine Aviation builds its future roadmap for both legacy and next generation systems survivability is part and parcel to the transformation.

As concepts and technology evolve to bring the OMFTS concept to fruition, survivability and its contribution to mission effectiveness remains the cornerstone of the Marine Corps Aviation transformation.

**MANPADS: The Vulnerability Challenge**

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When it comes to designing aircraft to survive the MANPADS threat, the high lethality of MANPADS and the difficulty in suppressing this threat goes to the issue of where to apply scarce resources: into more countermeasures and low observables or into vulnerability reduction features. Given that aircraft will be hit, some measure of vulnerability reduction appears prudent. A current challenge facing aircraft combat survivability involves addressing the MANPADS threat with a synergistic blend of susceptibility and vulnerability reduction techniques. Four major findings were derived from a recent JTCG/AS-sponsored study of aircraft-MANPADS interactions: 1) MANPADS have had a major influence on the character and implementation of airpower in war, 2) MANPADS hits do not necessarily result in aircraft kills, 3) potential vulnerability reduction solutions exist, and 4) more comprehensive data and analysis tools are required to advance the development of vulnerability reduction features. During the course of the study, technical deficiencies were noted giving rise to programmatic and technical survivability recommendations. Programmatic recommendations include 1) establishing a centralized MANPADS Project Office to lead a coordinated survivability effort, 2) developing new/innovative vulnerability reduction solutions proposed by industry, and 3) developing an Integrated Aircraft-MANPADS Survivability Plan-of-Action to guide tri-service activities. Technical recommendations include developing MANPADS test and hit-point databases, improving aircraft-MANPADS modeling methodologies, establishing a suite of MANPADS-capable vulnerability reduction techniques, developing a reliable IR missile warning sensor (to support the implementation of vulnerability and susceptibility reduction features), and preparing an Aircraft-MANPADS Survivability Design Guide. Implementation of the study's recommendations will transition to the aircraft design community and provide optimal and economical survivability solutions. By assuring balanced survivable designs early in the development process, aircraft will be able to withstand MANPADS hits, minimize operational risk, and regain lost battlespace.

**Challenges for the New Millennium**

**U. S. Air Force Perspective**

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Survivability permeates the essence of aerospace forces. Aircraft survivability is essential to gaining and maintaining air superiority across the battlefield. This presentation will address the Air Force perspective of survivability by describing the battlefield, survivability capabilities of our aerospace forces and long term capabilities needed into the 21st century.

The future Battlefield for Aerospace forces must center around Air Order of Battle and Ground Order of Battle. What they will look like in the future will shape the requirements process for the Air Force and also drive the way in which we employ our forces. Rules of Engagement have always played a significant role in the conduct of our

Air Campaigns. As we continue to become more involved with our coalition forces, the political restraints intertwined into ROE proves extremely challenging.

Survivability from a capability point of view revolves around standoff, stealth and suppression of enemy air defenses (SEAD). Standoff capability allows our forces to remain at the edge of threat rings or outside of threat range. Standoff in both the horizontal and vertical dimension allows aerospace forces to employ effective weapons while not sacrificing precision. The value of stealth has been seen in the F-117 and B-2 recently in Kosovo. Although stealth allows us to shrink threat rings, it does not make us invisible. Stealth will continued to be built into our air superiority forces as seen in the F-22 and Joint Strike Fighter. SEAD, in conjunction with stealth, provides a necessary capability. The ratio of our legacy to stealthy aircraft is still great, therefore, SEAD will continue to be a necessary requirement. The Air Force is progressing from SEAD to DEAD (Destruction of Enemy Air Defenses) through improvements in targeting pods, global positioning systems, precision weapons and improved electronic warfare and information warfare. DEAD will allow us freedom of maneuver in the future battlespace.

As we head into the new millennium, several technologies are needed to maintain aerospace superiority. We will be looking to space as well as aircraft for increased target identification capability, communication/datalink improvements. Improvements in weapons to include greater range and precision and speed require hypersonic, hyperspectral and advance target recognition features. Stealth and EW will continue to be important factors in aircraft survivability, as will UAVs. Directed Energy will also

prove decisive in future conflicts. Programs such as ABL, SBL, SBIRS and Discover II are leading the way in our transition from simply an air force to an aerospace force

# AIR WAR IN SERBIA: WARFIGHTER REPORT ON OPERATION ALLIED FORCE

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During Operation ALLIED FORCE, the 31st Air Expeditionary Wing conducted around-the-clock combat operations for 79 straight days as the largest wing in the history of both the United States Air Force and NATO. In all, 191 aircraft operated from Aviano Air Base, Italy, representing five NATO nations and all four U.S. services. The wing flew over 9,000 sorties for 40,000+ combat hours accounting for over 25 percent of the sorties flown in the conflict. Aviano aircraft delivered over 8,000,000 pounds of ordnance on Serb targets with smart munitions accounting for approximately 75 percent of the total. Two aircraft were lost over Serbia with both pilots being quickly rescued. Many factors influenced the ultimate success of the war in general, and aircraft survivability in particular. These factors included: training, command and control, rules of engagement, aircraft technology, weapons, self-protection hardware, intelligence, and combat tempo management. A review of these factors will provide a valuable point of departure for future operations.

AIRCRAFT SURVIVABILITY 1999

Title of Paper: Adapting to the Challenges of New Air Defense Threats and Combat Environments

Presentation Only

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There is no alternate.

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Classification of Presentation: Secret

Applicable Symposium Topic: Integrated Survivability

Brief Biography of Presenter: Mr. Hernandez received the BS in Electrical Engineering from California State University, Long Beach and the MS in Management from the Sloan Fellows Management Program at MIT. He joined Northrop in 1987 as a B-2 Project Engineer and was appointed Vice President in 1996. Prior to joining Northrop Grumman he spent 11 years with Rockwell International's Space Division where he was associated with the Space Shuttle and other advanced launch vehicle concepts.

ABSTRACT No. 2:

**Adapting to the Challenges of New Air Defense Threats and Combat Environments**

The success of integrated air operations, low observable aircraft and smart munitions in Kosovo and Iraq is likely to be challenged in the next millennium by new types of air defense weapons, unconventional sensors and major changes in tactical signal environments. However, new capabilities are also emerging to deal with these challenges. This paper provides an overview of many emerging challenges, assesses their potential impact on Aircraft Survivability and looks at new technologies to meet those challenges.

**INTEGRATED SURVIVABILITY ASSESSMENT AND DESIGN: CRUCIAL FOR THE FUTURE**

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Today's acquisition professionals are faced with numerous challenges such as acquisition reform, reduced fiscal resources, and competing design requirements and a mobile workforce. Ensuring that systems being acquired today, and in the future, possess the desired level of combat survivability is one of the single greatest challenges. To meet this challenge head-on, the design and assessment process must result in robust systems that can operate over a long service life in a variety of changing tactical environments. Most importantly they must continue to give our operators the advantage in combat. This presentation discusses the importance of achieving a higher level of integration in the design and assessment process.

The presentation discusses the importance of combat survivability in weapon system design, an importance that escalates at a rate similar to that of the cost and complexity of modern weapon systems. Survivability is important for many reasons, not the least of which, is simply ensuring we bring our operators back alive. Survivability is also the design feature that ensures we get the maximum benefit from our weapons systems and ensures that we sustain their already limited numbers. Survivability is truly a "force multiplier", that effectively extends the warfighting capacity of our defenses by "keeping them in the fight".

In developing new systems, program managers are faced with maximizing the effectiveness/cost ratio. They are compelled to manage requirements, schedule, and cost, while struggling to deploy an effective and survivable system. This is a constant process of trade-offs. Survivability has to "buy" its way onto the system during this process by demonstrating the benefits it brings to the table. Doing this with anything less than an integrated assessment approach typically results in what is known as point solutions, solutions that may solve a single, albeit, critical aspect of survivability, possibly at the full or partial expense of one or more other aspects critical to survivability. An effective integrated survivability assessment process must be employed to ensure such decisions are knowledge based and result in optimal effectiveness for the weapons system cost.

An integrated survivability assessment addresses issues at the "system level". It brings to the table, the ability to ensure the design will be robust throughout its life cycle. If employed throughout the design process, it will ensure supportable knowledge based trades. Trades that ensure the operators continue to have the advantage needed to get the job done.

The presentation will attempt to put in perspective the need for, and the benefits to be derived from, consistent employment of a well integrated assessment process throughout the development process.

# OPUS
## A Better Route to Mission Planning

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OR Concepts Applied has developed a suite of mission planning and analysis tools for the Air Force called OPUS (ORCA Planning and Utility System.) Initially designed for low observable platforms, OPUS contains features and utilities that are applicable to the planning of air operations for conventional aircraft.

OPUS is designed to provide the maximum degree of flexibility to accommodate changes in vehicle performance data, stand-off and fly-out weapons, threats, and other data. The core algorithms are data insensitive in that the user provides the prerequisite data files describing the objects attributes, performance, and characteristics. OPUS is an excellent tool to analyze how changes or improvements to weapon systems and associated threats affect overall mission performance and survivability.

Current OPUS capabilities include:

- An autorouter that produces threat avoiding, goal seeking, terrain aware routes for air vehicles with conventional or Low Observable (LO) Radar Cross Section (RCS) signatures.
- Innovative threat analysis techniques that result in route generation speeds far faster than traditional time step / ray trace approaches.
- A variety of figures of merit for attrition analysis and a documented C3I model. A SAM engagement model and an AI endgame model are implemented for both Monte Carlo simulation and static attrition analysis.
- Performs Payload Planning for a variety of sensor types including synthetic aperture radars and EO/IR sensor suites. The resulting plan includes sensor pointing instructions. Performs automatic search planning through relocatable target areas.
- Saves time in target area planning by automatically planning weapon releases that conform to common tactics for various weapons including standoff, gravity, precision guided munitions (PGM), and interdependent platform / smart weapon planning. Provides an alternative to manual weapon release sequence placement.
- Automatically plans weapon release maneuvers including heading constraints, straight and level times, damage assessment, navigational update, offset aim point imaging, and maneuvers that accommodate constraints of deliveries using GPS Aided Targeting Systems (GATS).
- Multiple resolution terrain model uses NIMA DTED but limits terrain data required in RAM without sacrificing resolution in critical areas. OPUS models terrain avoidance as well as defensive and offensive terrain masking effects. OPUS can develop TF/TA routes. A display tool allows viewing of the route's altitude profile and the underlying elevation data.
- An AFMSS interface has been developed that allows OPUS to be installed on an AFMSS workstation just as any other Aircraft/Weapon/Electronics (A/W/E) module. Data (e.g., threat lay downs, routes, and targets) can then be exchanged

OPUS can be configured as a stand-alone system or netted with other workstations. OPUS has the ability to import and export files to related mission planning systems such as AFMSS and CLOAR and has been used in conjunction with these systems to analyze mission survivability and effectiveness.

# ABSTRACT

A New EW Technique to Complement Reduced Signature Aircraft

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The paper will discuss monopulse radar angle jamming techniques and technology. It will include a brief history of monopulse angle jamming techniques such as Cross Polarization, Cross Eye, Mutual Protection Jamming, Terrain Bounce, and Towed Decoys. The paper will then describe a new monopulse angle jamming technique that is effective at short range. This new countermeasure technique is **complementary** with Reduce Signature platforms because the reduced signature prevents radar track at long range while the countermeasure technique prevents track at short range. The combination therefore prevents angle track at all ranges.

# *Developing Operational Tactics against Infrared Missile Threats*

NDIA Aircraft Survivability Symposium
Naval Postgraduate School
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16-18 Nov 99

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This paper demonstrates how the operational community bolsters aircraft survivability against the infrared (IR) missile threat by using engineering test data to modify flying tactics, techniques, and procedures (TTPs). Test data used in this example was obtained from a 1994 joint test and evaluation program, "Infrared Band IV Static Seeker Flyby Test" (Normally referred to as BAND IV). Seeker responses of nine IR missiles, including the US Basic Stinger, Stinger RMP, and other foreign systems, were evaluated against a full range of US military aircraft including the subject of this paper, the B-52H. A total of 137 missions were flown against ground mounted IR seekers. Aircraft included helicopters, attack aircraft, fighters, transports, and bombers. Each seeker was evaluated on its ability to establish and maintain lock on the target aircraft while the aircraft deployed flares, used jamming, employed both flares and jamming, or used flares and maneuver. Benign environments, those without countermeasures, were also evaluated for control purposes. As a result of these static flyby tests, training procedures, flying tactics, flare loads for expected threats, and flare dispense sequences were modified to improve operational counters to the IR missile threat.

This paper explores the results of the BAND IV test as they relate to the B-52H. More specifically, it relates BAND IV test results to subsequent changes in TTPs of operational B-52H crews. Combat procedures followed by operational aircrew are documented in tactics manuals or mission guides. These references are written and maintained by operational flyers using data, such as test reports, provided by the technical community. The BAND IV test highlighted mistakes in B-52 tactics, shortfalls in crew training, and strengths that could be exploited. The improvement processes followed by the B-52 community are indicative of those followed by the combat air forces (CAF) during the tactics improvement process and emphasize the criticality of alignment between the non-operational and warfighting communities. The paper is a primer for operational aviators to understand where the information that drives TTP changes comes from, and for the non-operational test community to see what the operational community does with the data they provide.

# IR COUNTERMEASURES FOR LOW OBSERVABLE AIRCRAFT

Abstract

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The goal of low-observable aircraft programs is to enhance the survivability of the platform in a missile threat environment. Infrared Countermeasures (IRCM) systems are a natural complement to the radar cross-section reduction (RCSR) measures of these programs since they provide enhanced survivability in an IR missile threat environment. With the recent advancements in IRCM technology, such as the development of lightweight, multi-band, IR laser systems, and the development of compact, high torque, turret pointing systems, active IRCM suites have evolved to provide the rapid response and high jammer intensity levels needed to offer protection to high performance aircraft. To date, however, limited effort has been placed on the development of reduced radar cross-section IRCM designs, which can provide CM protection while maintaining the low-observability of the host platform. This paper discusses the various approaches to RCS reduction that are appropriate to the design and installation of a lightweight, low-drag, directional laser IRCM system, suitable for use on low-observable aircraft.

A typical directional IRCM system configuration is first presented. Subsystem components are identified along with standard installation procedures and considerations relating to system placement on the host aircraft. Each subsystem component, which potentially impacts platform RCS, is then considered individually and an estimate is made of the RCS of significant scattering contributors. Finally, a discussion of the potential RCS reduction treatments and approaches applicable to the IRCM suite then follows.

## *ABSTRACT FORMAT:*

# DETERMINING THE FEASIBILITY OF VULNERABILITY REDUCTION TECHNIQUES FOR C-130 WING DRY BAYS

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The C-130 Vulnerability Reduction Program (VRP)/C-130J Live Fire Test Program, conducted by the Aerospace Survivability Flight (46 OG/OGM/OL-AC) at the Aircraft Survivability Research Facility at Wright-Patterson Air Force Base, is evaluating and demonstrating the effectiveness of candidate fire extinguishing agents in extinguishing ballistic threat-induced fire in C-130 wing leading edge, trailing edge, and engine area dry bays. Other issues to be addressed are C-130J composite propeller ballistic damage, Man-Portable Air Defense Systems (MANPADS), C-130 engine nacelle fire extinguishing, C-130 wing hydrodynamic ram, and mission abort.

Wing dry bay fires were identified as the major ballistic vulnerability contributor in a C-130H/J comparative vulnerability analysis completed in Sep 96. This analysis recommended survivability enhancement should focus on C-130 wing dry bay fire protection. A risk assessment of potential vulnerability reduction techniques determined dry bay fire extinguishing to be the lowest overall risk. The lowest current and short-term risk dry bay fire extinguishing alternative was assessed to be pentafluorethane ($CHF_2CF_3$), designated HFC-125, which is the USAF/USN/USA/FAA-selected Halon 1301 near-term replacement based upon the Halon Replacement Program for Aviation. Along with this agent, another fire extinguishing technology being evaluated in this program is a conventional Solid Propellant Gas Generator agent.

Testing began in the fourth quarter FY98 and concluded in Sep 99. Wing leading edge, engine area, and trailing edge dry bay replica wing sections were utilized for evaluation tests and C-130H production wing sections for demonstration tests. Over 150 tests were conducted, including live fire tests investigating dry bay fire vulnerabilities without the use of the aforementioned fire extinguishing agents. C-130 VRP testing and evaluation successfully developed and validated effective dry bay fire extinguishing masses for two fire extinguishing configurations. The C-130 VRP demonstrated the candidate agents in active fire extinguishing systems can feasibly extinguish ballistic threat-induced C-130 wing dry bay fires. If deemed necessary, the results of the C-130 VRP may eventually lead to the transition of this vulnerability reduction concept to production aircraft.

<u>ABSTRACT</u>

## *Air Force S&T Initiatives in Aircraft Survivability*

1999 Aircraft Survivability Symposium

16 – 19 November 1999
Monterey, CA

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As the U.S. military enters the 21st century, maintaining its technological supremacy in a period of downsizing, broadening military roles and increasingly sophisticated threats is becoming a significant challenge for the Air Force and all of DOD. To meet this challenge, the Air Force Science and Technology investment strategy is dedicated to the timely discover, development, and integration of affordable warfighting technologies for our Aerospace Forces. Over the years, we have made significant progress in establishing combat survivability to what we know today as a high-priority requirement for all our combat aircraft. Our investments in advanced research applications have paid significant dividends to the warfighter in terms of technological solutions, which increased combat effectiveness and saved lives. Our focus for the future will remain in continuing this life-saving trend, including susceptibility reduction and low vulnerability technologies, as well as associated cost and performance improvements.

Duration: 30 minutes
Classficiation: SECRET/US Only

# OH-58D RF SIGNATURE REDUCTION

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(U) The US Army Research Lab in cooperation with Bell Helicopter Textron developed a RF signature reduction kit for the OH-58D. This effort demonstrated the effectiveness of RF signature reduction for VTOL aircraft in a low to moderate clutter environment. This presentation will cover the initial research program, and subsequent production incorporation on a select number of special mission aircraft.

# THE MANPADS THREAT TO COMMERCIAL AVIATION: A TECHNICAL APPROACH

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The Federal Aviation Administration, Office of Civil Aviation Security Research and Development, Aircraft Hardening Program (AHP), in coordination with various research partners, have conducted several studies relating to the MANPADS threat to civil aviation. These tasks have ranged from identifying aircraft and airport vulnerabilities, to threat assessment and system exploitation. This technical effort is part of a plan to develop a data-base which will provide recommendations for aircraft survivability methods and techniques, and further develop empirical and analytical techniques for predicting the acquisition capability and eventual end game of MANPADS. With these lessons learned, the AHP (using FAA aircraft) is currently involved in a test series to determine a feasible method of reducing both aircraft susceptibility and vulnerability. In partnership with MSIC a test activity geared solely towards transport aircraft, is currently underway

## *ABSTRACT FORMAT:*

**Deceptive Electronic Countermeasures vs. Synthetic Aperture Radar**

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In the past 20 years, high-resolution terrain mapping and ground surface imaging sensor technology has rapidly advanced. Image information derived by airborne and spaceborne Synthetic Aperture Radar (SAR) sensors is becoming indispensable to planning by battlefield commanders. Such sensors can provide information on location, size, and deployment of enemy and friendly forces. Enemy forces can be detected (uncovered in a background terrain), identified and targeted. Eventually, complete SAR systems will be acquired by hostile and third world nations. During military conflicts, US ground forces on missions will have to be equipped with countermeasures capabilities to defeat the anticipated threat sensors. A need exists for a development of an EW system capable of deceiving the SAR imaging sensors.

This paper describes results of an IR&D supported analysis and computer modeling and simulation exercise conducted on the use of Deceptive ECM (DECM) techniques vs. an airborne SAR sensor. EW system requirements were derived based on the receiver processing capability of a typical SAR sensor. In principle, SAR is a coherent radar, but it vastly differs from a conventional pulsed doppler radar. A brief background is presented on the SAR fundamental properties, signal processing attributes, image resolution limitations, and potential susceptibilities to ECM.

A method was devised to generate ECM signal waveforms with modulation parameters capable of producing false images (range and angle false targets) at the desired locations on the SAR generated map. An ideal set of ECM waveform is one capable of producing images that conceal the target in the terrain background. To mask a target with the surrounding background is an extremely difficult task to accomplish. A practical SAR deception approach is considered: generate grouped false targets placed at distant locations. The false target images can be made to appear larger and more dominant than the real target. ECM waveforms are constructed from the intercepted SAR signals that are stored in a DRFM. To impart the proper modulation parameter values to the ECM

waveforms, the phase of the SAR signal is tracked. Thus, generated ECM signals can produce sets of credible false targets.

To produce DECM waveforms, an advanced Digital RF Memory (DRFM) is needed. The DRFM device must be wide bandwidth to accommodate the chirp signals and multi bit amplitude sampling. Its instantaneous bandwidth, number of amplitude bits, phase resolution, and input/output LO stability design requirements are specified. Jammer ERP requirements are derived on the basis of the SAR resolution capability and the number of desired range/angle false targets needed to produce an effective level of deception.

The presented results are supported with graphical illustrations produced by a Mathcad computer model. The computer model simulates the signal compression operation of a SAR matched filter receiver and produces a three dimensional response – range and angle ambiguity function. SAR receiver response is computed under dry and wet conditions and presented in a graphical form. Results of the analysis support the conclusion that the DECM vs. a SAR sensor is feasible.

## ABSTRACT

### Non-Conventional EW For LO Aircraft

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Low Observable (LO) aircraft are not immune to attack from hostile Integrated Air Defense Systems (IADS). Although current radar signature levels of LO aircraft do reduce threat engagement envelopes, there are specific, operating frequency ranges where physical constraints and cost limit the level of stealth achievable. Unfortunately, the use of conventional EW techniques and systems poses additional problems, since these approaches usually entail the addition of apertures which further compromise the cost and stealth characteristics of the host aircraft.

Many future LO aircraft incorporate Active Electronically Scanned Arrays (AESA) as the primary radar sensor. In principle, the AESA provides a wide-bandwidth, high-gain, high-power aperture organic to the host aircraft. Therefore, the AESA is a logical, potential candidate to provide EW functions for LO aircraft while minimizing the impact to the both the cost and stealth character of the host aircraft.

Northrop Grumman has conducted studies and demonstrations using its Independent Research and Development (IRAD) activities which explore and demonstrate the use of an AESA prototype as a Electronic Support (ES) and Electronic Attack (EA) mechanism. The briefing describes one such demonstration conducted recently using radar assets at Northrop Grumman facilities in Linthicum, MD, and those resident at USN facilities on Pax River.

The IRAD demonstration consisted of integrating elements of the Northrop Grumman Tactical - Radar Electronic Combat System (T-RECS) with an AESA prototype. The integrated system was then flown on a corporate BAC1-11 aircraft against each radar test facility. Both ES and EA functions were investigated. The flight-demonstration results are presented as part of the briefing.

## ABSTRACT

### A Timely Technology Transition for Towed Decoys

1999 Aircraft Survivability Symposium

16-19 November 1999

Monterey CA

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Air Force Research Laboratory
Sensors Directorate
AFRL/SNZW
WPAFB OH

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Raytheon SES
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For Electronic Warfare (EW), towed RF decoys can be considered the "cornerstone" of aircraft self-protection (and threat survivability). Through the joint, integrated efforts of Air Force Research Laboratory (AFRL), Northrop Grumman, and Raytheon, basic Microwave Power Module (MPM) technology was taken from a laboratory environment and successfully transitioned into the AN/ALE-50 towed decoy system. An MPM-based ALE-50 towed decoy now demonstrates significant RF performance improvements in the areas of efficiency, bandwidth and power densities. Large aircraft (historically limited in survivability) can now be fitted with a cost-effective solution to aircraft survivability.

This paper will provide a brief background on the ALE-50 towed decoy system, Microwave Power Modules, and the historical timelines of the when and how MPM technology was able to transition into towed decoys. The technical (system engineering and performance) details of the MPM for towed decoy architecture will also be described. Additionally, the teaming relationships between government and industry (key to this technology transition) will be discussed.

Duration: 20 minutes
Classification: SECRET/US Only

Abstract: **The JSF Approach to Combat Survivability**

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The Joint Strike Fighter (JSF) Program faces the problem of combining multiple services' needs into an affordable family of designs. These aircraft must accomplish and survive the varied missions put forth by the U.S. Navy, Marine Corps, and Air Force, as well as the United Kingdom's Royal Navy. Lethality, survivability, and supportability attributes must be balanced with affordability. These factors link many of the traditional survivability attributes to other air vehicle capabilities (e.g. sortie generation, low observables and maintainability; acquire the target, susceptibility, and electronic warfare).

An acquisition reform initiative allowed iterative requirements development by the warfighter. This was done in conjunction with the acquisition community's development of performance-based specifications and contractor maturation of the preferred weapon system concepts through Program Definition and Risk Reduction. The outcome would be the common ground for requirements and the resultant affordable designs.

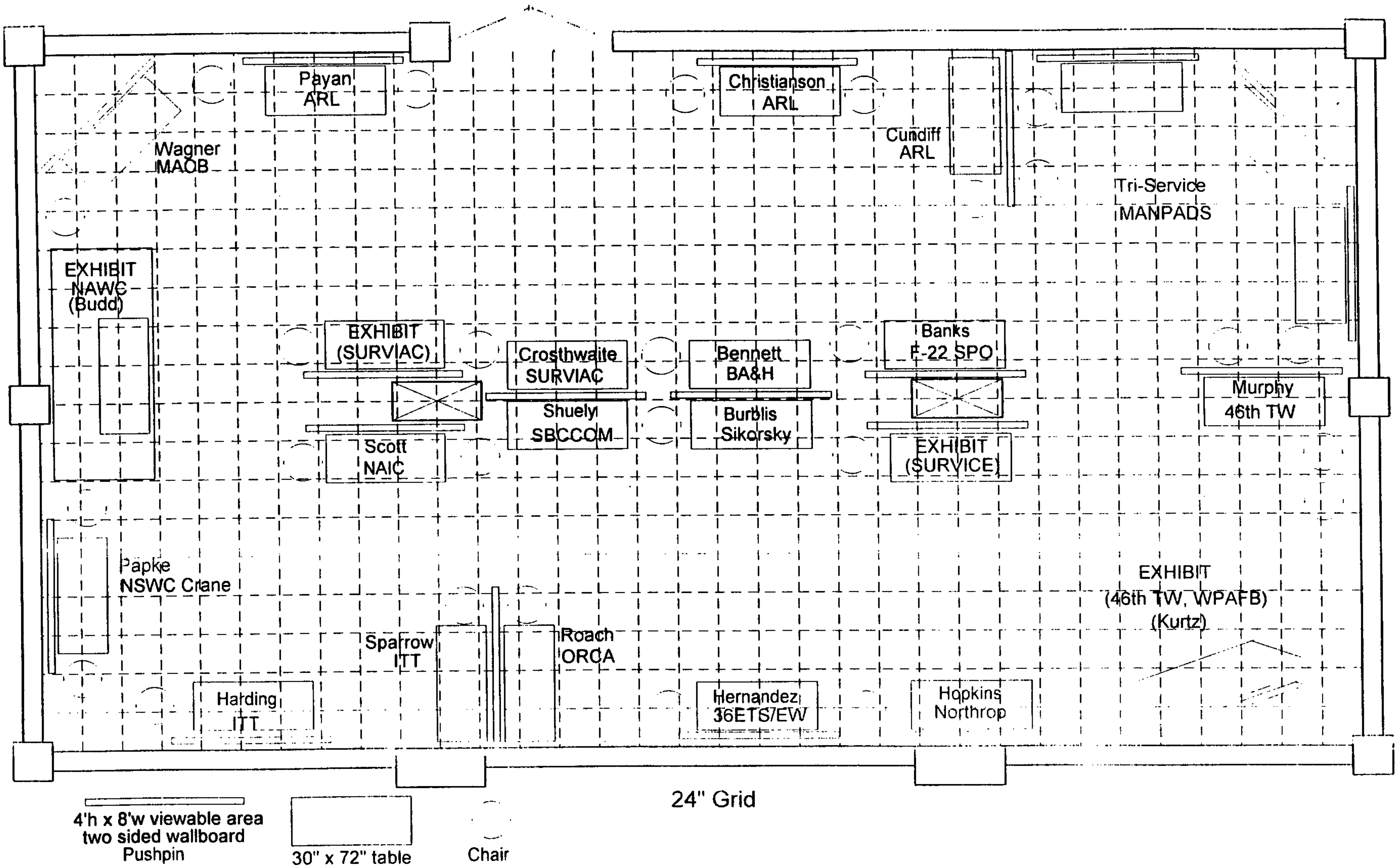
Cost and Operational Performance Trades (COPT) let the warfighters explore the effectiveness of various options within a Concept of Operations (CONOPS) for the JSF. This process was accomplished in the larger Cost as an Independent Variable (CAIV) framework and had advantages for risk management and feedback to the user on costs of desired capabilities. CAIV drove choices between competing capabilities and constrained some capabilities to fit within the target prices. When capability could not be achieved within the cost targets, decisions had to be made to remove a mission, limit capability, or add money to the budget to achieve minimum needed performance. These decisions included the survivability attributes of the JSF, mission capabilities, and total ownership cost of the air system.

The JSF attributes were prioritized by the warfighter through use of quality functional deployment tools in the strategy-to-task and task-to-technology processes. Functional flow analysis lead to mission level simulations where attributes of the JSF were assessed using the CONOPS with its various JSF missions and environments. Threats from the System Threat Assessment Report populated the environment (with ground rules and assumptions) in a generic composite scenario. The hierarchy of survivability attributes set forth by the warfighter included signature and susceptibility reduction to radio frequency and IR threats, situational awareness and countermeasures, and vulnerability reduction. The process captured the "operational" experiences of the warfighters using JSF and gave insight into the value of new JSF capabilities. The results affirmed priorities, caused changes in level of needed capability or lead to reordering the importance of some attributes. These needs are reflected in the ORD and are flowed into the performance-based specification.

# *Poster Abstracts*

# 1999 NDIA Aircraft Symposium Poster Session Room - Spanagel Hall

As of: 11-11-99



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## AIRCRAFT VULNERABILITY ANALYSIS TO MANPADS THREATS

As part of the JTCG/AS funded effort on MANPADS it was necessary to develop specific vulnerability data for the combinations of aircraft, MANPADS threat, and impact geometry to be evaluated in the study. A survey of previous assessments was first conducted to determine what methodologies had been used to generate the data and how the data had been used.

The survey showed that all previous assessments to this threat had been done solely to provide vulnerability inputs to missile end game models to support effectiveness studies for either aircraft or MANPADS design. No analyses for purposes of evaluating vulnerability resulting from a specific set of conditions or for vulnerability reduction had been done and documented. It was also determined that all previous assessments had been performed manually.

To meet the schedule and funding guidelines for this study a manual assessment technique was defined and used. It was applied for each of the two threats, four aircraft, and 20 impact points to be considered. The technique used the FASTGEN geometry program to generate drawings of the aircraft for each of the impacts being considered. The usual inboard profiles and three-view drawings of skin, structure, and components were generated, as were cross sections near the impact point. These drawings were then used with templates of the threat effects to determine the components destroyed or damaged and based on these, an engagement kill probability was assigned. Suggestions were also made concerning what might be done to reduce the vulnerability for the aimpoint.

The results were documented and provided for use in the remaining portions of the study. Suggestions for improving and/or automating the technique for future studies and for supporting test data to improve the analysis accuracy were also developed. Generally, the results showed that the engagement kill probability was very sensitive to the warhead design, the impact point, the impact geometry, and the aircraft design. They also showed that, while the MANPADS threats were very damaging to the aircraft, many engagements resulted in a high probability of the aircraft surviving. Consequently, it should not be assumed the kill probability is 1.0 for any aircraft/MANPADS encounter.

Note: This effort was funded by the Joint Technical Coordinating Group on Aircraft Survivability and managed by AFRL/VACS.

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OF ABSTRACT OR SUMMARY
DOES NOT ELIMINATE THE
REQUIREMENT FOR CLEARANCE
OF THE PAPER.

## COUNTERING THE CHEMICAL, BIOLOGICAL AND RADIOLOGICAL(CBR) THREAT

The characteristics of CBR warfare on the battlefield pose a very real threat for air vehicle operations, especially those operating in close proximity with the ground. Helicopter operations such as armed reconnaissance, attack, medivac, troop insertion, cargo delivery, and rescue missions would bear the brunt of the damaging characteristics associated with a chemical/biological attack. Each mission involves its own unique functions, which can assist in providing protection or can complicate the protective features by the tasks which have to be performed. To overcome this problem requires a dedicated understanding of the threat and its damaging characteristics. In addition, one must know which adversaries possess the capability to use it effectively, how it is weaponized, what are the latest deployment estimates and what protective equipment and/or features are available to counter the threat. Today's air vehicle designers are deticated toward producing a system which offers performance, capability, reliability, maintainability and survivability at an optimized gross vehicle weight while incorporating extensive cost reducing features. That ability to design, build and demonstrate a protective capability, along with bringing the entire design in within budget and at the allocated weight limit, is truly a significant engineering challenge. To accomplish this requires a dedicated focus on a design for mission performance and trade studies to tailor those design features incorporated. An understanding of the survivability features available for incorporation in the area of CBR protection is essential. Identifying those features, offering enhanced CBR protection, is a straightforward effort with the focus on several major categories such as detection, filtration, effective sealing, material hardening, communication, and overpressurization. However, once selected, incorporating those features can become a significant problem for the design community, which must address not only the protective aspects and all associated attributes but especially the weight and cost penalties. In summary, the design and production of an air vehicle system, which can operate effectively in a CBR contaminated environment, requires a thorough and realistic understanding of the CBR battlefield threat. This CBR assessment process will produce a solution for reducing air vehicle CBR vulnerability, based on threat, mission profiles and incorporated protective features, which results in a system designed for optimized CBR protection.

# *RUSSIA / CIS IADS INTEGRATION*

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Recent changes in Russian military structure as well as changes in several other Commonwealth of Independent States (CIS) raises questions about who, what, and how a CIS Integrated Air Defense System (IADS) would be organized, controlled and employed. The former Soviet Union had an effective IADS for defending their homelands. The Commonwealth of Independent States (CIS), headed by Russia, has been debating the idea of an IADS since the break-up of the Soviet Union. In 1995, seven CIS member countries signed an agreement to create the CIS Joint Air Defense. The main goal of this agreement was to integrate the CIS members' air defense capabilities into a functional IADS.

This paper examines the recent attempts by the CIS to secure a satisfactory defensive partnership with each other. The advantages and disadvantages of individual CIS member countries participating in a multi-country IADS are discussed. This discussion includes monetary, military, geographic, economic, ideology, ethnicity and political issues that are relevant to the topic.

Many IADS components of the Former Soviet Union (FSU) were based outside of Russia. There were many reasons for this including the perceived threat, location of member countries, and necessity of Russia to maintain military presence throughout all of FSU. Now that Russia has moved back into its 16th Century border it has lost assets that helped maintain and train IADS units, as well as strategic locations that provided a buffer for its border.

Russia and some of the other CIS member countries see a need to maintain a partnership that can ensure defense of their homelands. Each country member of the CIS has some asset, location, or capability that aided the FSU's IADS. Thus, integrated air defense was one of the prime factors in the initial establishment of the CIS. The cost to each individual country of providing the resources for an effective IADS is also a consideration for each CIS member country with an interest in a joint air defense system.

This point in history now leads the CIS members to a question: Do the CIS member countries feel that there is a significant threat to their homelands to warrant the expense, time and effort of developing an effective multi-national IADS? Russia has recently stated its concerns about western aggression and will continue to do so, but will other CIS members follow their rhetoric, or think for themselves?

**Information Systems Survivability Assessment for the Longbow Apache with Fire Control Radar**

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The U.S. Army Research Laboratory (ARL), Survivability/Lethality Analysis Directorate (SLAD) recently developed the Information Operations Vulnerability/Survivability Assessment (IOVSA) process to analyze and evaluate the survivability of information technology. The IOVSA evolved from the SLAD Information Systems Survivability Assessment (ISSA) which had been previously applied to aviation and ground systems.

Both processes support the analysis of U.S. Army weapon information systems in the information operations environment. To determine information systems survivability in the presence of information operations (IO) threats, the processes propose that five distinct phases be completed:

Phase 1 system familiarization,
Phase 2 system design/data flow analysis,
Phase 3 threat definition and assessment,
Phase 4 vulnerability assessment, and
Phase 5 protection assessment and recommendations.

Phases 1 and 2 consist of researching, documenting, and analyzing the system architecture and data flow. Phase 3 consists of identifying information operations threats and determining their likelihood of occurrence. Phase 4 consists of performing analytic and experimental assessments. Phase 5 provides recommendations to protect the system from the threat. Generally speaking, the complete analysis requires multiple years.

In FY98/FY99, SLAD implemented the ISSA process, to the extent possible, to determine within 1 year, whether the Longbow Apache (LBA) attack helicopter (AH-64D) with fire control radar (FCR) has susceptibilities to the information operation environment. The AH-64D LBA avionics system integrates all the hardware and software that enable the LBA to accomplish its mission. Distributed processing and redundant components support the nine subsystems that comprise the avionics system. The LBA interfaces with contractor and government-furnished, ground-based computer systems. These commercial computers perform mission planning, software loads, and aircraft maintenance and diagnostics. During a mission, the LBA uses a variety of interfaces to receive and transmit data and information.

# MANPADS – Combat History

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The Survivability/Vulnerability Information Analysis Center (SURVIAC) was tasked by the Joint Technical Coordinating Group on Aircraft Survivability (JTCG/AS) to gather data on aircraft vulnerability to the MANPADS threat. This task covered possible vulnerability reduction techniques, analytic tools, and testing. This data will be used to respond to an OSD initiative on the feasibility of reducing aircraft vulnerability to MANPADS.

As a part of the supporting data, SURVIAC gathered information on combat damage that has been inflicted on various aircraft by MANPADS. Historical combat with MANPADS dated from the early 1970's in Southeast Asia shortly after MANPADS were first fielded. Incidents from other conflicts including Yom Kippur and Desert Storm were collected. Individual terrorist and third world civil war incidents were also gathered into the MANPADS Combat History Database. The types of aircraft involved included fighters, bombers, transports, helicopters, and civil aircraft. Insight can be gained about the types of damage suffered, the frequency of damage in combat, encounter data on flight altitude and speeds, time of day, and mission type. Some aircraft design features appear to significantly reduce vulnerability to MANPADS. Many implications for future enhanced survivability can be drawn. The over riding conclusion is that while MANPADS are a potent threat, a hit is not equal to a kill; good survivability design practices can be effective.



Aircraft Survivability 1999, Monterey, California, 16 – 18 November 1999

AN MULTI-SPECTRAL APPROACH TO MISSILE DETECTION (U)

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Current missile warning systems are based on single color UV (IOC 1991) and both single and two-color IR sensors. Measurements performed by ARL at Westcott UK in 1993 during the NATO Research Study Group (RSG) 18 Field Trials demonstrated that there is another spectral region which demonstrates extremely good promise for missile detection. Certain effects were noted in the measurements of all current propellants: suppressed double base, unsuppressed double base, non-metalized composite, and metalized composite. Further radiometric, imagery and spectral measurements have been performed by ARL of static and in-flight Anti-Tank Guided Missiles and Surface-to-Air Missiles and similar phenomenology has been noted in all cases. The Office of Naval Research and Naval Research Laboratory became interested in the phenomenology in 1997 and it became a 6.2 EW New Start in FY98. Dr. Takken of NRL has developed a 6.2 prototype missile warning sensor with a 120 degree FOV. This was successfully tested during the October 1999 missile firings at the WSMR Cable Facility. The Navy plans to continue 6.2 work through FY01 and to transition to 6.3 in FY02. Dr. Bythrow is being funded by BMDO and others to develop spaced based systems based on the same phenomenology and has gained excellent data with extremely narrowband filters.

A Tri-Service meeting on this phenomenology was held at Wright Patterson Air Force Base on 14 September 1999. The phenomenology and quite recent technological and algorithm advances that permit it to be utilized were discussed. All service and academic attendees felt that the concept should have proof-of-principle in FY00 and be brought to the attention of the appropriate Army and Air Force Battle Labs.

The poster presentation will present spectral, radiometric, and imagery data obtained of static and in-flight ATGM, SAM, and strategic motors. Atmospheric attenuation and turbulence effects will be discussed and the technology advances that permit the use of the phenomenology will be demonstrated.

I

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## ABSTRACT

**"A Low Cost Techniques Generator for Next Generation Tactical Platforms"**

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Next generation tactical platforms, among them JSF, UCAV, and UAV, can benefit from a synergetic relationship between the air-vehicles' inherent / designed reduced radar cross-section and a low cost Radar CM system for enhanced survivability. ITT Industries, Avionics Division is conducting a study to produce a top-level design of a state-of-the-art ECM Techniques Generator (TG), that is low cost and can be used on a wide range of tactical platforms. The ALQ-211 TG subset of standard electronic modules (SEMs) and architecture are used as the baseline. This paper will present the requirements for a lightweight, low cost TG, which in conjunction with onboard transmitters and/or a towed, transmitting decoy would provide ECM protection that complements the platforms inherent survivability.

The low cost TG set of requirements was derived from parametric studies of representative reduced RCS, low observables, and very low observable platforms. The study objectives were to define the requirements (e.g. ERP, radiating pattern, techniques, threat handling capability, etc.) with an emphasis of complementing, not duplicating the platform's survivability. The top level design takes advantage of the modular nature of both the ALQ-211 system architecture and the individual SEMs to create a reduced SEM count, baseline architecture through SEM deletion and consolidation. This study also tackles the challenge of weight and cost reduction through the potential application of new / future technologies for subsystem design, resizing and replacement.

# ABSTRACT

**The Case for Periodic Reinvestigation of Threats for Mission Data Optimizations**

**by**

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Periodic revisitations of older, yet highly deployed threat systems is necessary to keep combat platforms on the cutting edge of electronic countermeasures (ECM), maximizing combat survivability through optimized ECM effectiveness. This presentation focuses on how:

- Increases in threat knowledge over time requires a revisitation of mission data (MD) optimizations
- Technology advances allow greater insights into processes of threats previously optimized against
- Improved analysis methods focus a MD optimization effort quickly toward areas of promise

Responsiveness is a key Air Power capability inherent in the process of MD development for ECM. Within the realm of electronic warfare (EW), non-emergency responsiveness typically is not present in revisiting radio frequency (RF) threats optimized against several years ago. With the wide proliferation and advancements made on older RF threats, MD revisitation makes good operational sense. These considerations will be presented in the light of recent MD optimization efforts against three well-known threat systems. Results of the optimizations will be presented with emphasis on how the three issues above, when acted upon, translated into significantly increased combat ECM effectiveness capabilities on several Combat Air Forces (CAF) platforms. The classification of this presentation is SECRET/NOFORN. The presentation is applicable to the session entitled "Countering RF Missile Threats".

Presenter is Mr. John Hernandez from the 36th Electronic Warfare Squadron, 53d Electronic Warfare Group, 53d Wing, Eglin AFB Florida. Presenter can be contacted at 850-882-4642 or by email: hernande@eglin.af.mil.

# ABSTRACT

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*Experience:* 20 years in Test and Evaluation. Aircraft experience consist of B-1B, F-16, F-15, F-4, F-111, A-10 and C-130. Involved in a number of Developmental, Qualification and Force Development Evaluations based around ALQ-131, ALQ-161, ALQ-165, ALQ-184, ALR-56M, ALQ-69, AAQ-13 Navigation and AAQ-14 Targeting LANTIRN, ASQ-213 HTS Pod, APG-63, APG-70, APG-66, APG-68, APN-241, APN-59, AGM-88 HARM, AAM-120 AMRAAM, ALE-50 and Arial Decoy systems. Participated on numerous Foreign Material Exploitation.

# ROTORCRAFT ANTI-HELICOPTER MINE (AHM) SUSCEPTIBILITY

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## ABSTRACT

The Army Research Laboratory (ARL) Survivability Lethality Analysis Directorate (SLAD) participated in the acoustic assessment of the MV-22 Osprey tilt-rotorcraft during its Operational IID (OT-IID) phase. During this study, ARL/SLAD instrumented a circular acoustic detection array using SLAD's Rotorcraft Acoustic Measurement and Detection System. As a Countermeasure (CM), SLAD deployed a Surrogate Anti-Helicopter Mine (SAHM) system. Anti-Helicopter Mines (AHMs) use acoustic sensors to alert the mine of the presence of an approaching rotorcraft system. Infrared sensors are used to trigger a lethal mechanism once the rotorcraft comes within the AHM's Zone of Authority(ZOA). The Rotorcraft Anti-Helicopter Mine Susceptibility presentation will introduce the SAHM sensor system and the results obtained from the MV-22 field investigation. The presentation will also include sample SAHM acoustic data and trigger imagery collected during the recent field investigation. The paper will also include the rotorcraft detectibility study and analyses, conducted by SLAD, during varying atmospheric conditions.

# ROTORCRAFT ANTI-HELICOPTER MINE (AHM) SUSCEPTIBILITY

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## MEASURING SURVIVABILITY
## OF
## INTEGRATED LO/EW SYSTEMS


### ABSTRACT

Aircraft survivability in a hostile environment is a function of its susceptibility to attack and its vulnerability if the aircraft sustains a hit. While designing to reduce vulnerability is concentrated on the mechanical airframe and components susceptibility tends to be divided into two distinct arenas – designs to reduce aircraft signatures by absorbing or diffusing energies and designs to "blind" threat systems by emitting energies or decoys to screen the aircraft.

This paper describes analytical tools and a methodology to develop routes employing aircraft signatures and active EW/ECM. Results of parametric studies conducted for a variety of signatures, EW/ECM tactics, and target threats are presented. The warfighter employing the same tools and methodology and actual signature data could determine an overall measure of mission effectiveness. The designer can also use the tools to perform comparative studies of real and theoretical systems for a variety of hostile environments and threat systems. The results of analytical studies and their application to LO vehicles are discussed.



M. Roach
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# NBC CONTAMINATION SURVIVABILITY REVIEW OF AIRCRAFT MATERIAL EVALUATION METHODOLOGY FOR DEVELOPMENTAL DECONTAMINATION SYSTEMS

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Chemical and biological contamination of aircraft is a Non-Traditional Threat that is becoming increasingly important. As an example, ultra-trace concentrations of chemical agents in or around aircraft can cause aircrew miosis. Recent additions to non-traditional threats have been recognized and are categorized as Toxic Industrial Chemicals (TICS) and Toxic Industrial Materials (TIMS). Briefly, these are commercially available toxic compounds that might be employed against various fixed sites, such as airfields and naval ports. Most new decontaminants under development are required to be effective against TICs and TIMs, in addition to traditional chemical and biological agents.

Aircraft decontamination generally falls under the sensitive equipment decontamination area. The difficulties in decontaminating advanced aerospace materials have been recognized by dividing the materiel development into two phases. A Phase 1 system will operate external to the aircraft. Phase 2 system(s) will be integrated into the aircraft for inflight decontamination. The Phase 1 candidate systems employ super critical fluids and various Freon replacement solvent systems, therefore, the material degradation issues involve the effects of super critical carbon dioxide or fluorocarbons on advanced electronic, optical, adhesive bonding, and related materials. The Phase 2 candidate systems might involve thermal desorption systems and. therefore, the material degradation issues could involve the effects of a transient thermal profile on aircraft interior instrumentation components. In addition, a fixed site decontaminating solution is under development and material compatibility issues involve the effects of candidate aqueous-organic decontamination solutions.

Methodologies are under development at ECBC for assessing the effects of Chemical/Biological contaminants and decontaminants on DoD materials. including advanced aerospace materials. Standardized test methods have been developed based on ASTM methods for chemical exposure to composites, thermoplastic transparencies, and elastomeric materials. Methods include sorption, desorption rate, and mechanical degradation effect measurements. The material operating limit (MOL) methodology for aircraft composites is being applied to contaminant and decontaminant exposure to aircraft composites. A change in the glass transition temperature of a material is being measured before versus after exposure to chemical contaminants and candidate decontaminants. Interactions and collaborations are being sought on developing or evaluating next-generation aircraft surface materials for NBC contamination survivability. Examples of chemical-materials evaluation capabilities will be presented.

Author Information Form

**Title: NBC CONTAMINATION SURVIVABILITY REVIEW OF AIRCRAFT MATERIAL EVALUATION METHODOLOGY FOR DEVELOPMENTAL DECONTAMINATION SYSTEMS**

X Poster Session Only

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Reconsidering Non-Conventional Threats

Biography: Wendel Shuely has over 30 years of experience in the investigation of chemical-material interactions relevant to DoD material degradation issues. Over the last ten years, the presenter has contributed experimental methodologies, material development, and material evaluation and ranking studies in support of chemical contamination survivability.

## *ABSTRACT FORMAT:*

### Deceptive Electronic Countermeasures vs. Synthetic Aperture Radar

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In the past 20 years, high-resolution terrain mapping and ground surface imaging sensor technology has rapidly advanced. Image information derived by airborne and spaceborne Synthetic Aperture Radar (SAR) sensors is becoming indispensable to planning by battlefield commanders. Such sensors can provide information on location, size, and deployment of enemy and friendly forces. Enemy forces can be detected (uncovered in a background terrain), identified and targeted. Eventually, complete SAR systems will be acquired by hostile and third world nations. During military conflicts, US ground forces on missions will have to be equipped with countermeasures capabilities to defeat the anticipated threat sensors. A need exists for a development of an EW system capable of deceiving the SAR imaging sensors.

This paper describes results of an IR&D supported analysis and computer modeling and simulation exercise conducted on the use of Deceptive ECM (DECM) techniques vs. an airborne SAR sensor. EW system requirements were derived based on the receiver processing capability of a typical SAR sensor. In principle, SAR is a coherent radar, but it vastly differs from a conventional pulsed doppler radar. A brief background is presented on the SAR fundamental properties, signal processing attributes, image resolution limitations, and potential susceptibilities to ECM.

A method was devised to generate ECM signal waveforms with modulation parameters capable of producing false images (range and angle false targets) at the desired locations on the SAR generated map. An ideal set of ECM waveform is one capable of producing images that conceal the target in the terrain background. To mask a target with the surrounding background is an extremely difficult task to accomplish. A practical SAR deception approach is considered: generate grouped false targets placed at distant locations. The false target images can be made to appear larger and more dominant than the real target. ECM waveforms are constructed from the intercepted SAR signals that are stored in a DRFM. To impart the proper modulation parameter values to the ECM

waveforms, the phase of the SAR signal is tracked. Thus, generated ECM signals can produce sets of credible false targets.

To produce DECM waveforms, an advanced Digital RF Memory (DRFM) is needed. The DRFM device must be wide bandwidth to accommodate the chirp signals and multi bit amplitude sampling. Its instantaneous bandwidth, number of amplitude bits, phase resolution, and input/output LO stability design requirements are specified. Jammer ERP requirements are derived on the basis of the SAR resolution capability and the number of desired range/angle false targets needed to produce an effective level of deception.

The presented results are supported with graphical illustrations produced by a Mathcad computer model. The computer model simulates the signal compression operation of a SAR matched filter receiver and produces a three dimensional response – range and angle ambiguity function. SAR receiver response is computed under dry and wet conditions and presented in a graphical form. Results of the analysis support the conclusion that the DECM vs. a SAR sensor is feasible.

## ABSTRACT

### Aircraft Survivability Issues and Lessons Learned from the Common Missile Warning System Military Worth Study

MacAulay-Brown, Inc., has recently completed a military worth study of the Common Missile Warning System (CMWS). This study, one of the first to be conducted under the guidelines of the SAF/AQ endorsed EW Partnership Process, required innovative analytical techniques to develop the targets-at-risk measure of effectiveness for three alternatives while constraining aircraft attrition to acceptable levels. Many interrelated concepts of aircraft survivability entered into this study at the one-vs-one and mission levels of analysis.

The poster paper will brief the issues of aircraft survivability which arose during this study, the analytical techniques which were developed to deal with these issues, and present results and lessons learned. Included will be discussions of integrating one-vs-one probability of hit and probability of launch data into mission level analysis as well as simulating CMWS and IR/RF countermeasure performance against the SAM threats in the study scenario. In addition, the paper will review guidance related to aircraft survivability received from the warfighter, various threat agencies, and study participants and demonstrate how it was incorporated into the study.

Greg Wagner